

THE RAINFALL OF BRAZIL.

ALFRED J. HENRY.

Dr. Sampaio Ferraz, the Director of the new Brazilian Meteorological Service, in his bulletin¹ of normal values presents monthly means of precipitation and other climatic elements for 91 stations throughout Brazil.

We are especially interested in the statistics of precipitation and have therefore summarized them for the benefit of readers of the REVIEW who may not have access to the original publication.

As indicated in the preface of the bulletin, it is concerned mainly with the observations made during the 11 years 1909-1919. It must happen, therefore, that in cases where the station was in operation prior to 1909 the full record of observations has not been included in the published mean values. Caution must therefore be used in regard to the mean values for certain stations. A single example will illustrate the point. Recife, sometimes called Pernambuco, has a rainfall record extending back into the eighties and it has been discussed in several publications; *Meteorologische Zeitschrift* for September, 1886, gives the annual mean as 2,972 millimeters (8 years). In the same publication for July, 1902, the annual mean 21 years' observations is given as 2,147 millimeters. The *Quarterly Journal Royal Met. Soc.* 36:57 gives the annual mean as 1,934 millimeters, 19 years' observation. The bulletin under discussion gives the mean as 1,193 millimeters, 9 years' observations, 1911-1919. Of course the differences in the annual mean here pointed out are due to the fact that different authorities have used periods of observation that differ from each in the years considered. Doubtless the adjustment of the earlier observation and the combination of the entire record in a homogeneous series is reserved for a future publication.

The geographical coordinates of the rainfall stations are given in the table below. The height above sea level given in the table is that of the barometer cistern at the station. This elevation will not differ materially from that of the rain gage.

TABLE 1.—Geographical coordinates of meteorological stations in Brazil.

State and station.	South latitude.	West longitude (Greenwich).	Establishment of station.	Elevation barometer cistern above M.S.L. (meters).	Altitude top of rain gage above ground (meters).
Amazonas.					
Manaus.....	3 08 1	60 01 5	Jan., 1910	44.9	14.0
S. Gabriel.....	0 06 7	67 02 1	Jan., 1910	.....	2.5
Parintins.....	2 38 0	56 44 3	Jan., 1910	.....	2.0
Boca Vista.....	2 49 0	60 41 3	Jan., 1910	.....	.....
Remate dos Males.....	4 20 6	70 23 9	Jan., 1910	.....	2.0
Coary.....	4 21 9	63 03 5	Jan., 1910	.....	2.1
S. Felipe.....	6 43 0	69 57 0	Jan., 1910	.....	2.0
Para.					
Salinas.....	0 35 2	47 21 5	Jan., 1910	.....	1.5
Maranhão.					
S. Luiz.....	2 31 5	44 16 8	Jan., 1909	20.0	1.5
Turyassu.....	1 42 8	45 26 5	June, 1911	15.0	1.5
Barra do Corda.....	5 30 5	45 15 9	Jan., 1912	81.0	1.5
S. Bento.....	2 40 8	44 50 8	Aug., 1912	11.0	1.5
Imperatriz.....	5 31 6	47 54 6	July, 1913	95.0	1.5
Ceará.					
Porangaba.....	3 46 7	38 32 6	Mar., 1911	27.0	1.5
Quixeramobim.....	5 16 0	39 15 1	Jan., 1896	207.0	1.5
Guaramiranga.....	4 15 8	39 01 4	Jan., 1911	825.0	1.5
Quixadá.....	4 55 4	39 08 3	Mar., 1911	180.0	1.3
Mondubim.....	3 46 1	38 34 7	Mar., 1911	.....	1.4
Macaty.....	4 37 0	37 45 3	Jan., 1910	.....	1.5
Rio Grande Do Norte.					
Natal.....	5 46 7	35 18 4	July, 1904	3.0	1.5
Nova Cruz.....	6 25 7	35 27 0	Aug., 1911	77.8	1.3
Macau.....	5 05 7	36 38 3	Jan., 1910	6.0	1.5

TABLE 1.—Geographical coordinates of meteorological stations in Brazil—Continued.

State and station.	South latitude.	West longitude (Greenwich).	Establishment of station.	Elevation barometer cistern above M.S.L. (meters).	Altitude top of rain gage above ground (meters).
Parahyba.					
Parahyba.....	7 6 6	34 56 1	Mar., 1912	30.0	1.5
Pernambuco.					
Recife.....	8 5 1	34 51 1	Jan., 1900	29.6	26.7
Fernando Noronha.....	3 50 0	32 55 5	Jan., 1910	85.0	1.5
Nazareth.....	7 46 7	35 15 2	Sept., 1911	82.0	1.5
Jaboatão.....	8 6 9	35 5 0	Aug., 1911	50.0	1.5
Goyanna.....	7 35 0	34 58 4	Aug., 1911	14.0	1.3
Pesqueira.....	8 45 0	35 15 0	Jan., 1913	.....	1.5
Garanhuns.....	8 53 4	36 24 1	Feb., 1913	848.0	1.5
Barreiros.....	8 22 4	37 14 0	Sept., 1911	725.0	1.5
Alagoas.					
Satuba.....	9 35 4	36 44 6	Jan., 1911	6.0	1.5
Pão d'Assucar.....	9 43 9	37 27 3	Oct., 1912	49.0	1.5
Maceió.....	9 40 2	35 44 0	Jan., 1909	.....	1.9
Sergipe.					
Aracaju.....	10 54 9	37 3 5	Jan., 1909	4.0	7.0
Bahia.					
Ondina.....	13 0 0	38 30 0	Jan., 1909	47.0	1.5
Caeté.....	14 2 0	42 38 6	Jan., 1909	900.0	11.5
S. Bento das Lages.....	12 35 0	38 45 0	Jan., 1912	32.3	1.5
Morro do Chapéo.....	11 32 9	41 14 4	Mar., 1913	1080.0	1.5
Rio de Janeiro.					
Campos.....	21 45 4	41 19 9	June, 1911	10.2	1.5
Vassouras.....	22 24 0	43 49 0	June, 1911	453.9	1.5
Rio de Janeiro.....	24 54 23	43 10 21	Jan., 1882	61.4	2.0
Rezende.....	22 28 4	44 26 8	May, 1911	399.2	1.5
Petropolis.....	22 30 9	43 10 0	Sept., 1912	813.0	1.5
Therzopolis.....	22 26 7	42 55 3	July, 1913	910.0	1.5
Friburgo.....	22 17 3	42 31 9	Jan., 1901	845.9	1.5
Alto do Itatiaia.....	22 24 8	44 50 0	Mar., 1914	2280.0	1.5
São Paulo.					
Maristella.....	22 57 7	45 12 5	July, 1912	600.0	1.5
Bandeirantes.....	22 36 0	44 28 0	Dec., 1913	533.2	1.5
Paraná.					
Paranaíba.....	25 34 0	48 30 0	Jan., 1910	4.0	1.5
Santa Catharina.					
Florianopolis.....	27 36 0	48 30 3	Jan., 1909	3.0	4.6
Therzopolis.....	27 48 0	48 45 6	Mar., 1911	220.0	1.5
Camboriú.....	27 1 6	48 38 3	Oct., 1911	5.0	1.5
Blumenau.....	26 55 3	49 9 2	Jan., 1884	24.0	1.5
Brusque.....	27 5 3	48 59 2	Jan., 1906	25.0	1.5
Curitiba.....	27 17 1	50 41 0	Apr., 1911	900.0	1.5
Ilha da Paz.....	26 11 5	48 30 7	Jan., 1909	.....	1.7
Itajaí.....	26 53 11	48 38 7	Mar., 1911	.....	1.4
Cabecudas.....	26 57 0	48 30 0	Jan., 1911	.....	1.4
Porto Bello.....	27 10 2	48 33 7	Apr., 1911	.....	1.6
Campos Novos.....	27 24 1	51 13 5	Mar., 1911	.....	2.0
Naufragados.....	27 50 5	48 34 7	Jan., 1911	.....	1.5
Rio Grande do Sul.					
Porto Alegre.....	30 1 9	51 13 2	Jan., 1910	11.2	1.5
Santa Maria.....	29 41 4	53 48 7	Jan., 1912	139.0	1.5
Uruguayana.....	29 45 2	57 4 8	Feb., 1912	374.5	1.5
S. Victorio do Palmar.....	33 31 2	53 21 8	Oct., 1912	5.0	1.5
S. Anna do Livramento.....	30 53 3	55 31 9	June, 1912	210.0	1.5
Minas Geraes.					
Belo Horizonte.....	19 54 9	43 55 7	Jan., 1910	857.0	1.5
Juiz de Fora.....	21 45 6	43 10 7	Jan., 1910	680.0	1.5
Cocambú.....	21 58 7	44 56 2	Aug., 1911	890.5	1.5
Mar de Espanha.....	21 56 0	42 47 0	Aug., 1913	450.0	1.5
Uberaba.....	19 44 6	47 56 2	Jan., 1897	760.0	1.5
Montes Claros.....	16 43 0	43 50 0	July, 1906	615.2	1.7
Pirapora.....	17 21 1	41 56 9	Jan., 1912	471.8	1.5
Theophilus Ottoni.....	17 45 0	41 26 3	Feb., 1911	905.0	1.5
Cachoeira do Campo.....	20 21 0	43 40 0	July, 1914	1104.0	1.7
S. João Evangelista.....	18 25 0	42 47 0	Jan., 1914	680.0	1.5
Oliveira.....	20 38 0	44 42 0	July, 1913	962.0	1.5
Aratuary.....	18 38 5	48 11 3	Oct., 1913	920.0	1.5
Monte Alegre.....	18 6 0	49 6 0	Nov., 1913	696.4	1.5
S. Francisco.....	15 56 9	44 52 2	June, 1912	449.8	1.5
Curvello.....	18 45 7	44 25 8	Sept., 1912	615.0	1.5
Januária.....	15 29 4	44 21 6	June, 1912	438.9	1.5
Goyaz.					
Goyaz.....	15 55 4	50 7 9	May, 1911	520.0	1.5
Catalão.....	18 10 4	47 58 3	Oct., 1912	830.0	1.5
Pyrenopolis.....	15 51 7	48 57 3	Apr., 1913	750.0	1.5
Formosa.....	15 32 1	47 18 3	Jan., 1913	912.0	1.5
Mato Grosso.					
Cuyabá.....	15 35 9	56 6 0	Dec., 1900	165.0	1.5
Corumbá.....	20 28 1	57 39 2	May, 1912	118.0	1.5
S. Luiz de Cáceres.....	19 00 0	57 41 7	May, 1912	118.0	1.5

¹ MO. WEATHER REV., June, 1922, 50: 309.

TABLE 2.—Monthly and annual means of precipitation at 94 stations in Brazil (in millimeters).

States and stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
<i>Amazonas.</i>													
Manaus.....	210.9	208.3	204.6	214.3	167.7	96.5	46.2	33.0	35.3	116.7	114.6	208.0	1,654.1
S. Gabriel.....	174.4	222.5	188.3	127.2	321.7	172.9	189.9	137.9	135.8	154.7	192.1	198.7	2,216.1
Parintins.....	175.5	215.5	348.8	257.7	222.1	140.1	105.8	83.6	45.2	68.1	90.0	112.3	1,864.7
Bôa Vista.....	15.2	60.6	95.0	129.9	210.2	329.8	240.6	181.1	43.2	43.6	16.9	29.9	1,396.0
Remate dos Males.....	374.3	285.6	385.6	293.3	268.5	151.6	143.5	164.0	165.8	273.6	269.2	361.6	3,137.5
Coary.....	240.8	260.9	271.9	251.2	217.7	131.2	80.8	74.1	94.7	147.1	133.5	211.6	2,115.6
S. Felipe.....	295.7	345.2	339.5	263.7	176.6	59.0	65.6	107.0	192.6	257.8	308.6	280.0	2,691.3
<i>Para.</i>													
Salinas.....	121.9	306.8	450.0	384.4	236.3	133.1	80.9	20.3	0.0	1.8	1.4	50.5	1,787.4
<i>Maranhão.</i>													
S. Luiz.....	190.5	243.9	477.7	416.4	320.7	144.9	114.9	29.8	12.4	10.6	18.1	68.9	2,048.8
Turyassú.....	228.2	309.2	425.0	417.6	237.8	210.8	132.4	69.1	11.0	11.5	11.4	57.4	2,157.6
Barra do Cordo.....	192.1	178.8	161.6	98.5	61.4	19.5	8.1	12.1	26.9	42.8	84.3	121.1	1,007.2
S. Bento.....	215.8	240.3	346.2	337.1	265.1	195.6	68.3	44.4	8.6	15.9	23.4	111.3	1,877.0
Imperatriz.....	262.1	245.5	249.8	153.7	112.2	11.5	10.7	20.5	20.1	74.8	80.1	169.1	1,410.1
<i>Ceará.</i>													
Porangaba.....	124.6	281.8	282.7	276.8	228.6	138.6	25.5	39.9	21.6	3.4	14.4	33.4	1,471.3
Quixeramobim.....	76.0	100.6	150.6	129.2	93.2	40.8	19.7	12.3	1.1	0.7	3.2	30.0	687.4
Gauaramiang.....	181.4	239.6	280.9	248.9	206.2	170.8	72.3	101.6	52.4	41.5	50.2	74.3	1,720.1
Quixadá.....	125.6	139.2	194.0	123.0	116.2	76.2	15.4	25.9	3.4	5.9	7.3	41.3	573.4
Mondubim.....	139.6	269.3	294.0	262.1	216.8	121.7	40.9	50.1	28.0	8.4	22.8	36.6	1,490.3
Macaty.....	79.5	186.7	370.9	247.0	105.4	53.1	17.8	20.5	7.6	10.1	8.4	39.0	1,146.0
<i>Rio Grande do Norte.</i>													
Natal.....	59.6	123.0	143.9	219.7	144.4	315.6	199.8	123.7	35.7	11.6	13.9	26.1	1,417.0
Nova Cruz.....	73.7	77.6	142.9	127.1	100.7	158.8	91.9	78.4	13.3	6.5	3.0	8.1	882.0
Macau.....	66.8	164.8	164.7	97.0	87.7	27.7	30.3	21.7	10.8	4.3	5.9	17.6	699.3
<i>Parahyba.</i>													
Parahyba.....	91.8	149.0	161.4	165.4	290.4	355.0	224.5	161.9	62.6	21.2	32.0	48.3	1,763.5
<i>Pernambuco.</i>													
Recife.....	46.6	106.7	115.2	95.1	235.8	205.3	155.6	130.0	42.2	15.3	20.0	25.0	1,192.8
Fernando Noronha.....	63.6	110.7	192.9	247.9	221.3	113.4	63.8	33.9	7.4	6.4	6.6	15.2	1,083.1
Nazareth.....	105.8	137.9	149.9	116.6	223.4	206.8	183.3	133.5	44.9	19.4	18.6	36.3	1,376.4
Jaboatão.....	123.6	188.9	186.6	178.7	329.0	375.7	298.1	224.5	88.2	32.6	36.2	47.3	2,109.4
Goyanna.....	106.0	166.1	158.5	164.8	263.1	266.8	191.0	152.8	58.7	19.0	29.6	31.8	1,608.2
Pesqueira.....	76.0	80.2	66.8	66.7	67.8	74.9	96.3	41.2	30.5	21.1	4.1	26.1	651.7
Garanhuns.....	75.3	63.0	42.3	84.3	132.5	160.4	150.6	124.9	53.6	14.9	16.7	49.8	998.3
Barreiros.....	130.1	160.4	162.3	159.9	416.9	457.2	408.6	333.6	170.1	55.5	45.2	65.2	2,560.0
<i>Alagoas.</i>													
Satuba.....	44.6	100.1	111.9	108.2	211.3	297.6	234.6	183.4	116.7	34.0	25.9	51.4	1,519.7
Pão d'Assucar.....	45.4	19.2	36.6	48.7	54.7	85.7	101.4	61.3	21.8	22.5	33.7	73.1	804.1
Maceió.....	75.3	87.6	191.5	146.2	346.1	284.8	236.5	170.6	108.7	44.2	27.5	58.1	1,777.1
<i>Sergipe.</i>													
Aracaju.....	38.9	45.6	105.9	86.6	171.1	128.3	119.2	69.2	39.7	63.1	22.5	57.2	947.3
<i>Bahia.</i>													
Ondina.....	82.2	122.8	138.8	245.4	259.0	242.6	187.4	123.3	83.7	118.9	119.7	152.4	1,876.2
Caeté.....	139.1	84.9	80.0	66.7	14.2	10.9	9.4	6.2	23.8	71.4	130.0	150.3	786.9
S. Bento das Lages.....	109.8	146.9	129.8	209.7	195.3	216.6	264.4	155.8	85.8	128.2	115.7	151.9	1,909.9
Morro do Chapéu.....	163.1	99.1	93.0	93.8	35.4	34.9	42.2	29.5	19.8	48.9	87.0	168.0	914.7
<i>Rio de Janeiro.</i>													
Campos.....	155.7	89.0	190.4	97.9	36.8	30.4	22.5	41.9	49.1	129.1	119.6	182.5	1,153.9
Vassouras.....	200.2	152.8	122.9	58.9	23.9	26.6	15.4	19.3	34.5	122.7	135.9	157.2	1,070.3
Rio de Janeiro.....	127.7	113.4	139.0	88.1	69.1	72.7	47.6	45.6	75.6	94.1	101.4	130.1	1,105.7
Rezende.....	296.8	246.8	150.7	110.0	33.5	35.6	31.1	28.5	52.1	130.9	177.4	241.9	1,535.3
Petropolis.....	292.6	227.1	308.2	157.5	84.7	67.4	60.8	66.9	72.1	188.1	323.3	273.5	2,122.2
Therzopolis.....	322.5	263.1	336.9	163.3	96.6	68.5	55.8	104.3	136.5	271.0	342.9	372.5	2,533.9
Friburgo.....	252.2	183.4	194.0	96.5	29.0	19.3	20.2	45.0	23.4	160.9	144.2	263.8	1,420.9
Alto do Itatiaia.....	387.8	383.9	273.6	192.1	54.1	50.6	57.9	61.0	69.7	204.5	254.2	343.0	2,322.4
<i>São Paulo.</i>													
Maristella.....	271.7	184.0	132.7	70.6	50.9	34.6	24.6	37.6	54.6	123.0	153.1	217.7	1,355.1
Bandeirantes.....	291.5	211.9	149.3	156.2	36.9	35.2	26.4	37.4	53.9	119.6	154.9	247.1	1,520.3
<i>Paraná.</i>													
Paranaguá.....	269.8	255.4	125.8	125.8	89.9	98.7	57.7	77.3	139.3	157.3	143.2	197.8	1,738.0
<i>St. Catharina.</i>													
Florianopolis.....	142.0	108.2	144.2	71.8	43.1	66.1	39.7	79.8	92.4	87.4	68.2	82.5	1,025.4
Therzopolis.....	225.4	248.4	190.7	92.1	49.8	119.8	70.9	109.9	235.7	119.5	120.5	128.7	1,711.4
Camború.....	187.1	205.4	149.1	93.7	72.0	89.8	49.6	92.6	115.5	104.7	97.1	127.5	1,383.1
Blumenau.....	203.7	263.2	168.1	96.9	61.1	103.5	51.6	100.4	117.5	101.1	74.7	124.2	1,466.0
Brusque.....	202.2	239.7	191.6	108.0	77.4	103.9	62.0	103.9	153.4	130.6	147.2	162.8	1,662.7
Curitiba.....	172.9	144.4	152.6	104.2	85.2	180.9	112.3	117.2	199.4	141.2	112.0	135.8	1,658.1
Ilhã da Paz.....	178.3	280.2	146.6	114.2	63.7	90.5	59.2	121.9	121.9	130.5	92.9	114.3	1,456.4
Itajaí.....	153.0	196.3	154.4	83.8	70.3	82.9	55.0	71.8	106.4	105.2	86.6	117.1	1,311.8
Caçobanas.....	124.1	179.5	157.5	96.9	72.6	79.7	62.3	76.9	108.4	76.6	89.6	91.2	1,205.3
Porto Bello.....	179.6	217.7	160.9	97.1	83.0	62.6	52.6	90.0	126.7	117.5	115.7	143.9	1,477.3
Campos Novos.....	129.5	143.6	143.5	117.1	111.1	180.9	120.7	120.8	192.3	142.9	126.4	116.4	1,645.2
Nau Frágidos.....	99.2	88.2	69.4	41.5	21.1	38.1	45.6	61.6	87.8	87.4	55.9	69.7	755.5
<i>Rio Grande do Sul.</i>													
Porto Alegre.....	121.1	85.5	89.1	124.9	118.9	125.1	99.8	144.9	128.9	68.9	90.1	102.5	1,299.7
Santa Maria.....	138.2	155.4	169.9	158.0	197.5	160.9	183.7	132.7	165.0	108.1	136.1	119.1	1,794.6
Uruguayana.....	95.6	100.5	169.1	174.7	153.4	98.1	79.6	74.4	102.4	104.4	111.0	87.9	1,351.1
S. Victorio do Palmar.....	95.8	115.2	133.6	91.5	148.4	62.0	115.2	105.4	139.1	89.2	83.7	87.0	1,264.1
S. Anna do Livramento.....	114.9	104.1	157.9	108.0	142.6	84.1	117.4	96.3	126.6	97.3	94.7	99.6	1,343.5

TABLE No. 2.—Monthly and annual means of precipitation at 94 stations in Brazil (in millimeters)—Continued.

States and stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
<i>Minas Gerais.</i>													
Pello Horizonte.....	329.9	224.2	163.6	71.8	15.9	12.1	10.3	23.3	37.2	126.3	208.1	277.8	1,433.1
Juiz de Fora.....	301.6	161.0	164.2	53.4	21.6	24.0	12.2	23.9	51.7	149.2	186.0	254.2	1,500.5
Caxambu.....	338.3	177.5	113.8	95.2	29.7	20.6	15.9	23.7	69.2	150.9	157.6	245.4	1,467.8
Mar de Espanha.....	267.7	120.4	139.3	81.3	43.1	25.9	12.1	31.5	33.5	137.1	152.4	235.7	1,280.0
Uberaba.....	256.8	220.0	232.8	148.1	42.9	29.0	12.6	23.2	37.2	104.8	218.9	264.7	1,621.0
Montes Claros.....	307.5	154.1	133.4	78.2	31.6	1.3	3.0	12.5	14.3	127.6	189.5	233.0	1,236.0
Pirapora.....	330.8	166.9	172.1	98.2	35.5	25.0	4.0	16.5	30.6	101.3	151.6	241.2	1,246.7
Caeophlo Ottoni.....	216.5	129.4	177.2	129.0	100.3	35.9	22.1	24.7	28.7	119.3	225.2	243.8	1,450.1
Cachoeira do Campo.....	274.5	178.1	118.2	124.3	52.3	29.5	11.8	32.1	35.3	130.2	232.0	309.6	1,525.9
S. João Evangelista.....	254.6	147.5	176.6	116.8	29.0	22.0	9.9	33.8	38.9	131.8	244.0	318.9	1,534.7
Oliveira.....	308.7	179.4	215.1	63.9	28.0	26.5	14.4	26.5	35.0	134.0	196.8	248.0	1,507.3
Araguari.....	324.9	302.2	248.6	167.7	14.4	16.0	20.7	12.1	44.3	187.4	256.6	419.5	2,024.6
Monte Alegre.....	191.3	145.3	78.1	35.4	18.1	14.4	9.8	30.2	136.2	261.8	330.6	280.1	1,334.3
S. Francisco.....	300.4	141.3	142.8	88.9	28.9	0.6	5.3	9.6	25.2	104.7	224.3	269.4	1,339.9
Curvello.....	242.3	107.3	174.0	109.4	15.1	11.1	11.7	13.9	38.9	87.5	207.6	271.9	1,280.7
Januária.....	207.6	97.3	118.2	94.4	12.0	1.2	8.6	5.6	36.0	85.9	170.2	228.8	1,065.8
<i>Goyaz.</i>													
Goyaz.....	307.7	276.0	294.9	124.5	10.6	12.7	0.2	11.2	43.6	123.4	219.2	264.3	1,688.3
Catalão.....	334.6	247.7	254.6	115.2	33.0	8.9	14.0	8.8	67.4	190.1	223.6	362.8	1,860.7
Pirenópolis.....	286.6	229.4	304.3	119.1	35.6	5.7	6.1	11.5	32.8	142.2	210.4	266.5	1,650.2
Formosa.....	360.3	221.5	166.3	135.1	19.1	3.0	4.5	28.7	48.5	135.0	201.0	376.2	1,699.2
<i>Matto Grosso.</i>													
Cuiabá.....	240.7	214.9	232.9	119.6	48.8	3.9	6.2	51.1	50.1	104.5	165.6	221.9	1,460.2
Corumbá.....	196.1	158.4	122.9	123.8	84.7	47.7	7.1	34.1	57.9	101.6	151.1	189.7	1,245.1
S. Luiz de Cáceres.....	200.7	208.4	145.1	96.2	50.8	18.0	5.6	20.4	48.6	109.6	182.5	190.3	1,276.2
<i>ADDITIONAL STATIONS.</i>													
<i>Ceará.</i>													
Fortaleza ¹	80.0	179.0	297.0	341.0	237.0	120.0	55.0	29.0	16.0	13.0	13.0	38.0	1,418.0
<i>São Paulo.</i>													
Alto da Serra.....	414.0	396.0	382.0	304.0	214.0	192.0	170.0	204.0	272.0	318.0	348.0	400.0	3,614.0
Santos ¹	302.0	235.0	345.0	212.0	164.0	178.0	114.0	122.0	143.0	152.0	201.0	249.0	2,447.0
São Paulo ²	231.0	217.0	157.0	75.0	74.0	57.0	31.0	52.0	86.0	114.0	133.0	193.0	1,423.0

¹ Quart. Jour. Roy. Met. Soc. XLV: 69. For the years 1849-1915.² Idem, p. 61.

The rainfall statistics of Table 2 have been grouped by States beginning with the most northerly Amazonas. A cursory examination emphasizes what is already well known, viz, that vast areas in Brazil are not adequately represented by existing meteorological stations. The great interior States of Amazonas, Para, and Matto Grosso having a combined area of four and a quarter million square kilometers are represented by 11 rainfall stations all of which have sufficient length of record to be incorporated into the bulletin of normals. This would give a single station to each 402,190 square kilometers (155,291 square miles).

Various writers have distinguished at least five distinct types of rainfall in South America according to whether there is a single or double maximum and minimum and the season of the year in which the maximum occurs. A simpler classification might be based on the monthly distribution in which we should have a type of single maximum and minimum, respectively, regardless of the time of year they occur. The second type would logically be those distributions which have a double maximum and a double minimum in the course of 12 months, and finally there would be the type in which the monthly distribution is more or less uniform.

The five types now commonly recognized are as follows: (1) A double maximum in the equatorial regions separated by intervals of relatively less rain; (2) a season of well-marked maximum in the rains which may occur in any of the four seasons. There will be, therefore, four subtypes under (2), viz, Winter, Spring, Summer, and Autumn, each of which will obtain in different parts of the continent. Finally, a sixth type, the type of uniform rains is recognized.

In the Tropics the altitude of the sun seems to be the most important control of rainfall; other causes are operative but it is not easy to segregate them. The rainfall of Brazil is best understood by a consideration

of the characteristics of the coast as compared with the interior. The coast of Brazil stretches from about 4° north latitude to 33° south latitude. In that distance both the amount and the monthly distribution vary considerably.

I have prepared a series of 24 graphs which illustrate the monthly distribution at a number of points on the coast and in the interior. It is helpful to begin the series with what may be called the oceanic type for the South Atlantic northeast of Cape St. Roque. The meteorological station on the island of Fernando Noronha, established in 1910, furnishes the data for the graph No. 1 of Figure 1. That island is 125 miles offshore and in the region of the southeast trades. The maximum precipitation of the year is reached in April and there is then a rather rapid diminution in the amount until November. Zenith sun is reached on the island on the 1st of April and during that month pressure falls to the lowest point of the year. The wind circulation of the South Atlantic is largely dominated by the strength and position of the semipermanent South Atlantic anticyclone whose normal winter position is within the triangle formed by the islands of Helena, Tristan da Cunha, and Trinidad. The barometer level in this anticyclone sinks to 30.10 inches in April; it is then least effective as a wind control on the Brazilian coast. The prevailing winds at Fernando Noronha during summer (Southern Hemisphere) December-February are southeasterly becoming more southerly in February and backing to between southeast and east in March, April, and May. The force of the winds in January is on the average 6.8 meters per second falling to 5.7 in March and rising to 6.4 in April and 6.8 in May. The greatest force of the wind, 8 meters per second, is reached in July (winter of Southern Hemisphere.) The direction, however, is practically the same throughout the year, viz, southeast to east.

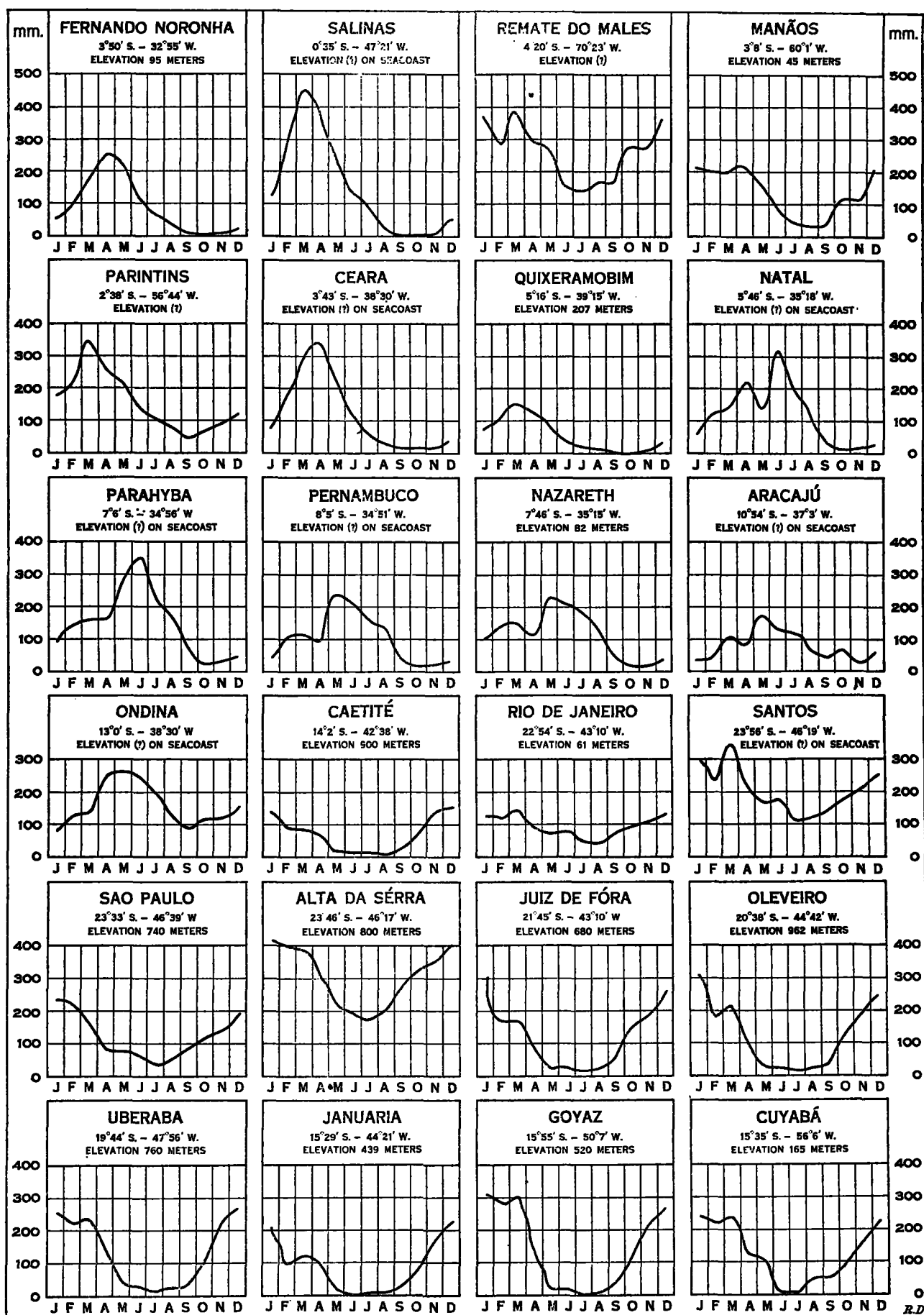


FIG. 1.—Graphs of mean monthly precipitation at various South American stations.

On the coast of Brazil, as at Pernambuco, the prevailing winds are not materially different from those of Fernando Noronha, except that in certain months as in February, May, June, August, October, and November the easterly component in the wind at Fernando Noronha is greater than on the coast.

There is but a single maximum of rainfall on the island and that is coincident with zenith sun. The double maximum which appears in South America is absent, although the island is within about 4° of the equator. This may argue that the double maximum elsewhere in South America is largely a continental effect. B. C. Wallis² says:

It is usual to associate rainfall near the equator with the idea of two maxima and two rainfall minima, but the maps fail to indicate the prevalence of such conditions in Africa. Broadly the rainfall within the tropics is distinguished by one period of great rainfall intensity followed by a period of small intensity, so that a graph of rainfall within the tropics should resemble a temperature graph for a place about 50° N, showing a period of intense rainfall shading off to a period of gradually smaller intensity, until the dry season is reached and at the same time it will be apparent that a rainfall graph within the tropics is of constant shape, the maximum occurring when the sun is most powerful; hence the most potent rainfall factor in tropical Africa is the elevation of the sun above the horizon.

Passing now from the oceanic to the coastal type it is seen that at the Equator on the Brazilian coast as at Salinas there is a strongly marked maximum in March followed by a decided minimum in September, October, and November. There is no evidence of the double maximum and minimum which prevails in the interior quite remote from the coast. It seems also that the coastal type does not prevail very far inland since the graph for Parintins about 400 kilometers inland in 2° 38' south latitude shows but little trace of a double maximum or minimum. The time of the maximum on the coast is a month earlier than in the oceanic type and the amount of rainfall is decidedly greater, both conditions probably being due to the continental background afforded the rain bearing winds. The coastal equatorial type also prevails in Maranhao, as exemplified by the graph for S. Luiz. In the adjoining State of Ceara to the south, are found more or less arid regions in the interior and the same may be said of the States of Rio Grande Do Norte and Parahyba. The rainfall on the Coast of Ceara is illustrated by the graph for the station of the same name. Even on the coast the rainfall of some years is greatly diminished.³ The graph for Ceara shows the same type of monthly distribution as for the coast of equatorial Brazil, except that the time of maximum is deferred until April.

On the coast of Rio Grande Do Norte, Parahyba, Pernambuco, and Alagoas, which States embrace the great bend toward the eastward in the continent of South America, there is seen a shifting of the time of yearly maximum rainfall from autumn toward early winter (Southern Hemisphere).

On the coast of Rio Grande Do Norte and Parahyba there is evidence of a secondary maximum in April corresponding to the time of the principal maximum nearer to the Equator. See the graphs for Natal, Parahyba, and Pernambuco.

Proceeding down the coast into higher latitudes the simple equatorial type is much modified and there is a tendency toward the uniform distribution of the Tem-

perate Zone. On the coast of Rio de Janeiro and Sao Paulo, however, there is a rather well-marked maximum in March with a minimum in the winter months—June, July, and August.

The interior.—Naturally great areas in the interior are not adequately represented in the statistics of rainfall which appear in Table No. 2. Amazonas, however, is represented by seven stations, and these show a range in the annual precipitation from a minimum of 1,396 at Boa Vista to 3,137.5 millimeters at Remate dos Males. The double maximum type of rainfall prevails in the larger part of Amazonas but the second maximum in October is not so well pronounced as the primary in March or April—see the graphs for Manaus and Remate dos Males.

The winds in the middle Amazon Valley as at Manaus are mostly light east with northerly component, January to March, inclusive, and a southerly component during the remaining months, except in December when the northerly component again appears.

Through the courtesy of Dr. F. L. Hoffman, Consulting Statistician, the Prudential Insurance Co., Newark, N. J., the Weather Bureau is able to present a table of rainfall for Porto Velho on Madeira River in latitude 9° south and 64° degrees west, approximately. The measurements have been made by the engineering department of the Madeira-Mamore Railway Co. Fortunately the monthly totals are available and they will be found in Table No. 3, next below.

TABLE 3.—Monthly and annual precipitation at Porto Velho, Amazonas, Brazil, approximate position lat. 8° 44' south, long. 64° 0' W. Elevation unknown (inches and hundredths).¹

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1908.....	14.93	10.66	19.65	4.59	4.79	1.63	0.37	2.36	1.35	9.28	13.74	18.85	102.21
1909.....	11.23	13.91	13.42	8.19	6.33	.10	.02	.00	2.72	7.62	6.50	19.71	89.84
1910.....	9.78	10.42	9.81	10.83	1.87	.09	.50	1.69	5.42	9.28	8.31	9.12	77.12
1911.....	13.62	15.96	9.56	10.64	1.97	1.09	.17	6.77	1.86	6.07	16.21	10.93	88.75
1912.....	14.43	7.92	8.57	7.37	5.06	1.08	.07	.72	4.26	10.61	10.42	9.52	80.03
1913.....	11.25	10.48	13.08	10.12	1.12	.00	.13	1.87	3.73	6.26	4.40	6.57	69.01
1914.....	7.99	11.00	8.90	5.04	2.63	1.43	.09	.34	.86	3.18	2.03	5.06	48.55
1915.....	5.66	5.80	6.03	3.07	2.92	.00	2.62	4.91	6.29	5.64	11.21	9.87	63.82
1916.....	20.30	13.66	9.28	11.66	4.25	1.13	.00	1.56	2.72	3.64	11.58	12.27	92.08
1917.....	17.53	8.78	16.53	10.65	3.84	.30	.29	.00	.00	3.69	9.15	9.00	79.76
1918.....	5.04	17.13	17.41	7.56	7.81	.79	.31	3.73	5.52	9.64	13.95	24.46	113.35
1919.....	8.62	21.05	25.11	12.02	6.89	1.41	.14	2.24	6.25	22.78	19.59	17.17	143.27
1920.....	24.82	20.31	15.91	10.64	10.24	2.72	2.21	4.80	7.41	18.33	14.83	20.77	152.99
1921.....	24.48	11.27	18.78	12.13	7.60	2.67	.51	4.37	2.52	8.67	.....	.....	.....
Means.....	13.55	12.72	13.72	8.89	4.81	1.03	.53	2.10	3.64	8.91	10.92	13.34	94.16

¹ Observations made under direction Engineering Department, Madeira-Mamore Railway. Furnished by F. L. Hoffman.

Porto Velho belongs to the type of a single well-pronounced maximum in summer (Southern Hemisphere) with an equally well-marked minimum in June, July, and August.

In the interior of the dry States of northeastern Brazil the distribution throughout the year follows the oceanic type with the period of greatest rains in April. According to Draenert⁴ the drought in the northeastern States is due to the fact that the regions affected lie in the rain shadow of certain mountains which stretch northeast-southwest through the States above mentioned.

The type of distribution in the interior of Pernambuco differs from that of the coast only in the fact that the

² Scottish Geographical Magazine 36:365.

³ cf. Mossman in Quart. Jour. Roy. Met. Soc. 45:69-79.

⁴ F. M. Draenert, Die Vertheilung der Regenmengen in Brasilien, Meteorologische Zeitschrift, Sept., 1896.

season of greatest rain is slightly later and the amount is greater at points favorably situated with respect to the sea winds. On the other hand, places in the rain shadow of the mountains receive less rain than on the coast.

In Bahia the inland type as represented by the station Caetité is nearly opposite to the coastal type in that the greatest rains occur in the months November–April and the least in winter June–August.

With increasing distance from the Equator the monthly distribution tends toward the equality of the Temperate Zone, although distance from the sea and topographic factors are still controlling influences. The three stations in São Paulo whose graphs are given in Figure 1—Santos on the coast, Alta da Serra, a seaward-facing slope station about 15 kilometers inland, and São Paulo on the interior highlands about 50 kilometers inland—show a considerable difference in the monthly distribution. Santos on the coast has a chief maximum in March, while the slope station, Alta da Serra, has a decided maximum in the summer months, December to February. The total annual amount of rain at that station is, moreover, the greatest reported for any station in Brazil, doubtless due to the topographic factor. The concluding group of interior stations beginning with Juiz de Fora and concluding with Cuyaba illustrate the characteristics of monthly distribution in the interior of the States of southern Brazil. A feature common to all of them is a rainy season in summer and a dry season in winter.

MAXIMUM PRECIPITATION IN 24 HOURS.

Voss, speaking of the maximum precipitation in Brazil for 24 hours, says:⁵

By far the greatest rainfall within 24 hours fell in the State of São Paulo, Brazil, on the eastern slope of the Serro do Mar at an elevation of 230 meters at kilometer No. 22, on the wire-cable railroad Santos to São Paulo. Here on March 29, 1898, a rainfall of 417 millimeters (16.42 inches) occurred. At just double the elevation at kilometer 25.2, 313 millimeters fell on the same day and at the end of the line, elevation 800 meters, the fall was only 61 millimeters (2.40 inches).

The record of maximum rains in 24 hours in Doctor Ferraz's bulletin refers, of course, to the period 1909–10. I have summarized the data by States and present the results in the table below. The arrangement of States is in the order of magnitude of the 24-hour rains.

TABLE 4.—Maximum precipitation in 24 hours (by States).

States.	Amount.		States.	Amount.	
	Milli- meters.	Inches.		Milli- meters.	Inches.
S. Catharina.....	288.3	11.39	Alagoas.....	162.7	6.40
Maranhão.....	222.7	8.76	Goyaz.....	160.0	6.30
Minas Geraes.....	202.7	7.98	Parana.....	153.0	6.02
Ceara.....	201.9	7.95	Pernambuco.....	146.1	5.78
Amazonas.....	201.0	7.91	Matto Grosso.....	133.6	5.25
Bahia.....	193.0	7.60	Rio Grande do S.....	133.4	5.25
Para.....	177.6	6.99	Sergipe.....	122.1	4.81
Rio Grande do N.....	174.0	6.85	Parahyba.....	119.0	4.68
Rio de Janeiro.....	173.0	6.81	São Paulo.....	98.4	3.87

⁵ Voss, Ernst Ludwig, Die Niederschlagsverhältnisse Südamerika, Ergänzungsheft No. 157 Petermanns Mitteilungen. 8. 30.

THE ETESIENS.

By J. S. PARASKÉVOPOULOS.

[National Observatory, Athens, Greece, May 25, 1922.]

Introduction.—The characteristic north winds which blow during the summer in the region of the eastern Mediterranean, are known as the etesiens. The periodic nature of these winds has been observed since the time of the ancient Greeks, their marked regularity being noted by Hesiodus. In fact, it is because of this characteristic regularity that they are called etesiens.¹ The name itself means "winds blowing periodically every year." Aratus has written on this subject in his *Phenomena*, from which we quote the following:

When the corn has been harvested and the sun is approaching the constellation of Lion, then the etesiens blow with their full strength in the open sea; navigation with oars is not possible and I want then a large boat.

Theon, the commentator of Aratus, explained the name in a double way:

The etesiens blow from the time of the morning rising of the constellation of Canis Major, during, at the most, 60 days. They are called etesiens either because they blow each year during certain days, or, more truly, because they are sure to blow when their season comes. At that time, large boats are necessary, because the waves are high and the wind stormy.

Characteristic features of the etesiens.—The method of determining the period during which etesiens blow in Greece has been as follows: I have divided the month into 10-day periods and noted the number of days during which etesiens have blown in each period rather than counting the number of days in each month. This method has been applied to observations extend-

ing over 15 years (1900–1914) and is based on the observations made at the Greek meteorological stations. At these stations observations are made three times daily; at 8 a. m., 2 p. m., and 9 p. m. (Athens mean time). I have selected four stations in the Aegean Sea (Andros, Syra, Naxos, Santorin) and three in the Ionian Sea (Corfu, Zante, Cephallonia). For the station at Athens I have used observations from self-recording apparatus.

Table 1 gives the average number of days having north winds. I have considered as north winds all winds between the directions ENE., N., WNW.

In examining the tabulated results, especially those from the stations of the Aegean Sea and Athens, I found that these summer north winds fall into two definite periods. The maximum of the first period, which is also the shorter, occurs during the last 10 days of May while the maximum of the second period takes place during July and August. The etesiens are thus divided into two classes known as *prodroms* and *etsiens*. Generally speaking etesiens blow from the second 10-day period of May until the middle of October, with two periods of maximum, as just mentioned.

During the first period the etesiens are less strong and more intermittent than during the second. During June these winds are interrupted, and not very frequent. In July and especially in August they are, on the contrary, much more steady and frequent but their occurrence diminishes continually throughout September and October. This distinction was observed as early

¹ The etesiens are known in the Orient under the Turkish name *meltem*.